

**Fractal Variety and Contrast:
A Low-Carbon Fuel for Inspiration and Innovation**

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Keynote Address**

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Distinguished Guests.

I am truly grateful for the opportunity to speak at this year's low-carbon development forum. Nothing is more important for the survival of humanity than to move from a way of living that is unsustainable under current technological and resource constraints to a way of living that is more sustainable. Your commitment to work seriously in this domain is, in my opinion, a mark of nobility.

This is the third year in which I have had the honor of speaking to this gathering of highly accomplished scientists, government officials, and successful leaders of business. Please understand that I am not a scientist; I am therefore not an expert on what must be done to move successfully to a more low-carbon way of living. My observations about these issues will instead reflect my experience helping teams of people to combine their talents in pursuit of a shared goal.

When I spoke to this conference two years ago, the theme was low carbon generally, and the topic of my remarks was fear. I spoke about how important it is to recognize that work in this area is difficult, and that it is human nature to become paralyzed by the fear that progress in this field is impossible and therefore that our efforts are futile. I urged all of you to follow four guidelines to overcome that natural fear – that you break problems down, that you know yourself, that you keep an optimistic heart, and that you work collaboratively.

When I spoke to this conference last year, the topic was “Z cubed” -- zero carbon emissions, zero waste water, and zero pollution. And I spoke about the value of goals that cannot be attained. You are all working to address the greatest challenge humanity has ever confronted – the challenge of sustainability in the age of global development. I spoke of how valuable it is to set the goal of zero as our horizon, and to march courageously in that direction, even if we know we can never get there.

When I looked at this year’s program, I was immediately struck by how all of you are pushing past the natural human fear of failure. And I was immediately struck by how successfully you are making progress in the direction of the unattainable “zeros” that are our shared goals.

And I was surprised to notice a third fact:

The ultimate goals that we are all aspiring to are beautiful to state. Greater sustainability. Discovering ways to live that bring us into greater harmony with our environment and with one another.

To reach those beautiful goals, we must take specific, concrete steps. It is at the level of specific, concrete steps that we must be inspired and we must innovate. You, the participants in this conference, are the people who are experiencing that inspiration and are bringing about that innovation.

So here is the third fact that surprised me about this conference. In seeking inspiration that will enable you all to innovate in the pursuit of beautiful goals, it is startling how consistently you are prepared to look closely at things that are ugly.

Water is beautiful. Solid waste is ugly. Energy is beautiful. Greenhouse gases are ugly. Harmony is beautiful. Resource tradeoffs are ugly.

But then, upon reflection, I decided that I should not be surprised that you enjoy looking at the beautiful and the ugly together. If you are seeking inspiration, nothing could be more natural than to put the beautiful and the ugly side by side.

Inspiration is not something we fully understand. But it is not a matter of random chance. When it comes to inspiration and innovation, the

environment must matter. The context must matter. Our personal experiences cry out to us that some environments promote inspiration and innovation better than others.

So this morning I would like to share with you one hypothesis that I have about inspiration and innovation. We can call it Lehman's Conjecture. I believe that inspiration and innovation are promoted by environments that are complex rather than simple. I believe that inspiration and innovation are promoted by environments that are heterogeneous rather than homogeneous. I believe that inspiration and innovation are promoted by environments that are multidisciplinary. I believe that inspiration and innovation are promoted by environments that are diverse.

And please allow me to add one refinement to Lehman's Conjecture. We can call it Lehman's Lemma. I do not believe that it is enough for the environment to be complex and diverse at a high level of generality. I believe that the complexity and diversity must be carried forward deeply into the structure of the environment, in the manner of a fractal. In other words, it is not enough to say that the environment includes one large clump of X's, another large clump of Y's, and a third large clump of Z's. It is much better if wherever you look, you see XYZ's and ZYX's and XZY's.

Why is this kind of fractal diversity important? It is important because it creates frequent contrasts. If we juxtapose things that are different from each other, if we put them side by side, we create variety and contrast. And I believe that variety and contrast are critical stimuli for the human brain. I believe that variety and contrast are fuel for inspiration and innovation.

We live in an age when neuroscientists are making daily breakthroughs in understanding how the human brain works. And I will bet that somewhere on earth a neuroscientist has proved that environments full of variety and contrast trigger much higher levels of brain activity than environments that are dull and boring.

So when I reflect upon the value of fractal variety and contrast, it helps me to understand how it is that the community attending this conference is so comfortable juxtaposing beauty and ugliness. This juxtapo-

sition stimulates our brains. It promotes innovation. It creates the kind of fertile soil out of which inspiration might blossom.

And that understanding in turn gave me an even greater appreciation for the manner in which this conference was designed. Dean Geng and his colleagues have created an environment that is not merely diverse along only one dimension. It is not merely diverse along two dimensions. No, they have put forth the effort required to make this environment diverse along three dimensions.

First, the participants in this conference are diverse along the dimension of intellectual discipline. We have gathered here chemists and physicists, engineers and biologists, planners, climatologists, and even a lawyer. People from different academic disciplines carry different intellectual tools. And some of the most important challenges we face require us to use a lot of different tools in order to surmount them.

Second, the participants in this conference are also diverse along the dimension of professional calling. Many of you do research in the context of universities. Many of you do research and other work in the context of businesses that must transform a theoretical insight into a practical improvement in the way that people live. And many of you are government officials who have a public responsibility to create environments where university researchers and private businesses can be successful.

And just as was true for people from different academic disciplines, it is also the case that people from different professional callings carry different intellectual tools. They are trained to ask different kinds of questions. They are trained to focus their attention on different features of a problem. And once again, when we are talking about problems of sustainability we are talking about problems that will yield only if teams of people from different professional callings work together to address them in all their complexity.

Third, the people attending this conference are diverse along the dimension of nationality and culture. Participants in this conference come from China, Japan, Singapore, the United States, and elsewhere. And participants in this conference grew up in very different cultural backgrounds.

For many years now, cognitive psychologists have been looking carefully at the way that people from different cultures perceive the world differently. Almost a decade ago, Richard Nisbett gathered together the results of a number of studies that suggested that people from some cultures are more attuned to foreground and others more attuned to background, people from some cultures are more attuned to the nodes on a network and others more attuned to the links between those nodes.

I believe passionately that – just as was true with differences in academic discipline and professional calling – we obtain a more profound understanding of the world when we work together with people from different cultures. We see properties and relationships that we could not see if we looked from only one perspective. And we need to be able to draw on those deeper insights if we are to continue to make progress as a species.

So permit me to conclude my remarks this morning with a request. The designers of this conference have created an extraordinary three-dimensional variety here, at a high level of generality.

I am asking you to make the variety of this conference fractal. Please resist the very natural temptation to seek out people who are similar to yourself. If you are a Japanese chemist from a university, go look for a Chinese government official with a background in biology. If you are an American businessman who studied engineering, go look for a Singaporean physicist who works at a government research institute.

If you follow that advice, then this conference will fulfill its promise. It will be a stimulus to new innovation and to inspiration. It will enable us all to take further steps down the beautiful path to a more sustainable future.